Designation: D732 – 17

Standard Test Method for Shear Strength of Plastics by Punch Tool[1]

This standard is issued under the fixed designation D732; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the procedure for determining the shear strength of plastics in the form of sheets, plates, and molded shapes in thicknesses from 1.27 to 12.7 mm (0.050 to 0.500 in.).

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D4000 Classification System for Specifying Plastic Materials

D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens

E4 Practices for Force Verification of Testing Machines

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 *shear strength*—the maximum load required to shear the specimen in such a manner that the moving portion of the load fixture has completely cleared the stationary portion, divided by the sheared area. It is expressed in mega-pascals (or pounds-force per square inch) based on the area of the sheared edge or edges.

4. Significance and Use

4.1 Shear strength obtained by the use of punch-type tooling is one of the recognized methods of comparing materials, or obtaining data for engineering design purposes, or both. However, it must be recognized that for end-use applications there are likely to be many factors not taken into account in this test method, such as stress-concentrating geometries and rates of shear, which can profoundly affect the measured shear strength. Moreover, the fact that the shear strength is calculated by dividing the load by the area of the sheared edge (punch circumference *X* specimen thickness) does not interpret as indicating the shear strength value so obtained is solely a material property, independent of thickness.

4.2 For many materials, it is possible that there is a specification that requires the use of this test method, but with some procedural modifications that take precedence when adhering to the specification. Therefore, it is advisable to refer to that material specification before using this test method. Table 1 of Classification System D4000 lists the ASTM materials standards that currently exist.

5. Apparatus

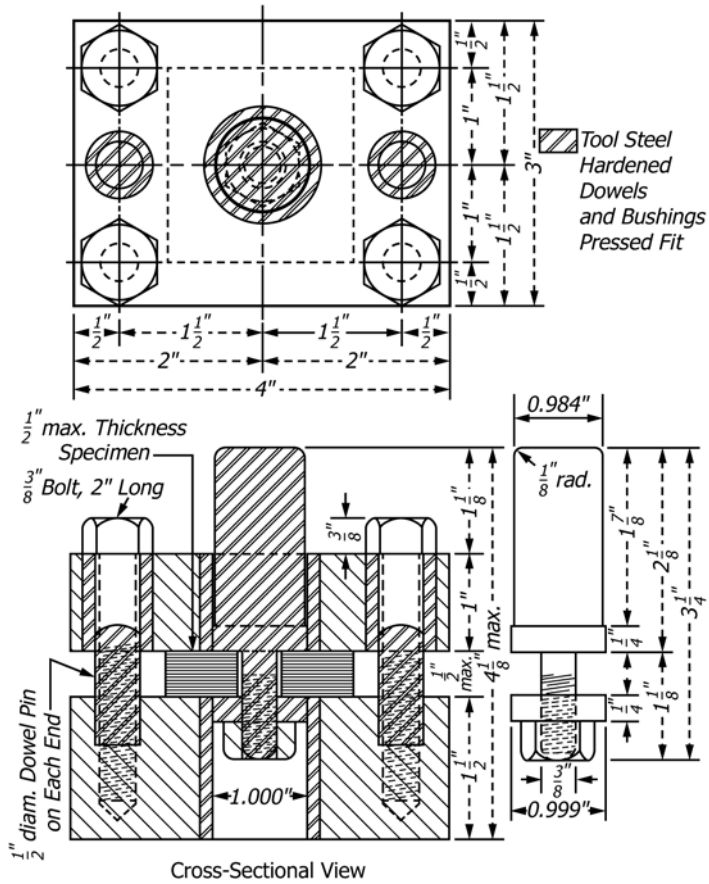
5.1 *Testing Machine*—Any suitable testing machine of the constant-rate-of-crosshead movement type. The testing machine shall be equipped with the necessary drive mechanism for imparting to the crosshead a uniform, controlled velocity with respect to the base. The testing machine shall also be equipped with a load-indicating mechanism capable of showing the total compressive load carried by the test specimen. This mechanism shall be essentially free from inertia-lag at the specified rate of testing and shall indicate the load with an

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

Current edition approved May 1, 2017. Published June 2017. Originally approved in 1943. Last previous edition approved in 2010 as D732 – 10. DOI: 10.1520/D0732-17.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard



NOTE 1—In case of difficulty in obtaining hardened dowels and bushings, the entire shear tool may be made from a fairly good grade of steel, eliminating all of the bushings shown. The actual working surfaces will wear faster than when hardened tool steel is used. When they show signs of appreciable wear, the shear tool can then be bored out to take either hardened or unhardened bushings, depending upon which are available.

FIG. 1 Punch-Type Shear Tool for Testing Specimens 0.127 to 12.7 mm (0.050 to 0.500 in.) in Thickness

accuracy of ±1 % of the indicated value or better. The accuracy of the testing machine shall be verified in accordance with Practices E4.

5.2 *Shear Tool*—A shear tool of the punch type which is so constructed that the specimen is rigidly clamped both to the stationary block and movable block so that it cannot be deflected during the test. A suitable form of shear tool is shown in Fig. 1.

5.3 *Micrometers*—Apparatus for measuring the thickness of the test specimen shall comply with the requirements of Test Methods D5947.

6. Test Specimen

6.1 The specimen shall consist of a 50-mm (2-in.) square or a 50.8-mm (2-in.) diameter disk cut from sheet material or molded into this form. The thickness of the specimen is limited from 1.27 and 12.7 mm (0.050 and 0.500 in.). The upper and lower surfaces shall be parallel to each other and reasonably flat. A hole approximately 11 mm (7⁄16 in.) in diameter shall be drilled through the specimen at its center.

6.2 A minimum of five specimens of each sample material shall be tested. If fewer than five specimens are tested, the report shall reflect that results are based on a modified version of the standard.

7. Conditioning

7.1 *Pre-Test Conditioning*—Condition the test specimens in accordance with Procedure A of Practice D618 unless otherwise specified by contract or the relevant ASTM material specification. Conditioning time is specified as a minimum. Temperature and humidity tolerances shall be in accordance with Section 7 of Practice D618 unless specified differently by contract or material specification.

7.2 *Test Conditions*—Conduct the tests at the same temperature and humidity used for conditioning with tolerances in accordance with Section 7 of Practice D618 unless otherwise specified by contract or the relevant ASTM material specification.

8. Procedure

8.1 Measure the thickness of each test specimen to the nearest 0.025 mm (0.001 in.) at a minimum of three points on a circle approximately 12.7 mm (0.500 in.) from its center. Average the readings and record as the specimen thickness.

8.2 Place the specimen over the 9.5-mm (3⁄8-in.) threaded pin of the punch and fasten it in place by securing the washer and nut tightly.

TABLE 1 Shear Strength

Material[A]	Values Expressed in Units of Pound-Force per Square Inch					
	Average Thickness, in.	Mean	S_r[B]	S_R[C]	r[D]	R[E]
RIM	0.134	2900	32	155	92	439
HDPE	0.071	3410	27	135	76	382
Polyester	0.128	8580	57	278	163	788
SMC	0.210	14 700	304	569	862	1610
Polyester[F]	0.0104	10 200	384	1950	1080	5530
PCTFE[F]	0.0076	7900	528	2730	1490	7740

[A] The complete designations for the materials in Table 1 are: reaction injection molding (RIM), high-density polyethylene (HDPE), sheet molding compound (SMC), and polychlorotrifluoroethylene (PCTFE).
[B] S_r is the within-laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories: $S_r=[[(S_1)^2+(S_2)^2 \ldots+(S_n)^2]/n]^{1/2}$.

[C] S_R is the between-laboratory reproducibility, expressed as standard deviation: $S_R=\{S_r^2+S_L^2\}^{1/2}$ where S_L is the standard deviation of laboratory means.

[D] r is the within-laboratory critical interval between two test results = 2.8 × S_r.
[E] R is the between-laboratory critical interval between two test results = 2.8 × S_R.
[F] Values for 0.010 in. thick polyester specimens and 0.007 in. thick PCTFE specimens are included in Table 1 to show that the repeatability and reproducibility of shear strength values were greatly inferior to corresponding data obtained on specimens of 1.780 mm (0.070 in.) minimum thickness. Therefore, the scope of this test method was revised to limit test specimen thickness to the range from 1.27 to 12.7 mm (0.050 to 0.500 in.).

8.3 Center the specimen and punch on the support fixture and complete the assembly of the clamping fixture being sure to tighten the bolts securely.

8.4 Load the test specimen at a crosshead speed of 1.27 mm (0.05 in.)/min. The tolerances shall be 1.3 ± 0.3 mm (0.050 ± 0.010 in.)/min.

8.5 Push the punch far enough through the specimen so that the sheared section clears the specimen proper. The specimen will then be adjacent to the necked-down portion of the punch, and it can then be readily removed from the tool.

NOTE 2—For thick specimens of some materials the punched-out piece tends to stick in the die. If the test is continued only to the point where maximum load has been developed and starts to fall off rapidly, the specimen may be readily removed from both punch and die.

9. Calculation

9.1 Calculate shear strength in mega pascals, MPa, (or pounds-force per square inch, psi), determined by dividing the load required to shear the specimen by the area of the sheared edge, which shall be taken as the product of the thickness of the specimen by the circumference of the punch.

10. Report

10.1 Report the following information:

10.1.1 Complete identification of the material tested, including type, source, manufacturer's code number, form, principal dimensions, previous history, etc.,

10.1.2 Method of test, type of test specimen, and dimensions,

10.1.3 Atmospheric conditions in the test room,

10.1.4 Conditioning procedure used,

10.1.5 Diameter of punch,

10.1.6 Load in newtons (or pounds-force) required to shear each specimen, and the average value, and

10.1.7 Shear strength in megapascals (or pounds-force per square inch) for each specimen, the average value, and the standard deviation.

11. Precision and Bias[3]

11.1 Table 1 is based on a round-robin test conducted in 1983, in accordance with Practice E691, involving six materials tested by eleven laboratories. Each "test result" was the average of five individual determinations. Each laboratory obtained one test result for each material. (**Warning—**The following explanations of r and R (11.2 – 11.2.3) are intended only to present a meaningful way of considering the approximate precision of these test methods. The data given in Table 1 should not be applied rigorously to the acceptance or rejection of materials, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 11.2 – 11.2.3 would then be valid for such data.)

11.2 *Concept of r and R in* Table 1—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages from testing five specimens for each test result, then:

11.2.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the r value for that material. The r value is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

11.2.2 *Reproducibility*—Two test results obtained by different laboratories shall be judged not equivalent if they differ by more than the R value for that material. The R value is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D20-1120.

11.2.3 The judgments in 11.2.1 and 11.2.2 will have an approximately 95 % (0.95) probability of being correct.

11.3 *Bias*—It is not possible to make any statement about the bias of this test method, as there is no standard reference material or reference test method that is applicable.

12. Keywords

12.1 punch tool; shear strength